

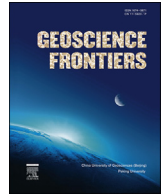
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Research paper

New early Eocene vertebrate assemblage from western India reveals a mixed fauna of European and Gondwana affinities



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ABSTRACT

The Ypresian Cambay Shale Formation at Vastan and Mangrol lignite mines in Gujarat, western India, has yielded a rich vertebrate fauna with numerous taxa of European affinities. Here we report a new, approximately contemporary vertebrate assemblage from two fossiliferous layers in the nearby mine of Tadkeshwar. These layers have yielded a similar mammal fauna with the co-occurrence of the perissodactyl-like cambaytheriid *Cambaytherium thewissi*, the adapoid primates *Marcgodinotius indicus* and cf. *Asiadapis cambayensis*, and thehyaenodontid *Indohyaenodon raoi*. The presence of these species in both Vastan and Tadkeshwar mines and at different levels suggests that the deposits between the two major lignite seams represent a single land mammal age. Apart from the aforementioned species there is a new, smaller species of *Cambaytherium*, and a new genus and species of esthonychid tillodont. This fauna also contains the first large early Eocene vertebrates from India, including an unidentified *Coryphodon*-like pantodont, a dyrosaurid crocodyliform and a new giant madtsoiid snake. Among the Tadkeshwar vertebrates several taxa are of Gondwana affinities, such as Pelomedusoides turtles, dyrosaurids, and large madtsoiids, attesting that the early Eocene was a crucial period in India during which Laurasian taxa of European affinities co-existed with relict taxa from Gondwana before the India-Asia collision. Our results suggest that terrestrial faunas could have dispersed to or from Europe during episodes of contact between the Indian subcontinent and different island blocks along the northern margin of the Neotethys, such as the Kohistan–Ladakh island-arc system. Gondwana taxa might represent remnants of ghost lineages shared with Madagascar, which reached the Indian subcontinent during the late Cretaceous; alternatively they might have come from North Africa and passed along the southern margin of the Neotethys to reach the Indian subcontinent. These dispersals would have been possible as a result of favourable paleogeographic conditions such as the particular Neotethys conformation during the beginning of the early Eocene.

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1. Introduction

The Cambay Shale Formation, exposed at the Vastan open cast lignite mine near the Vastan village about 40 km northeast of Surat, Gujarat, western India (Fig. 1), is known since 2004 for its well-preserved diverse fauna of terrestrial mammals as well as other vertebrates (e.g., Rana et al., 2004, 2005; Bajpai et al., 2005a, 2009;

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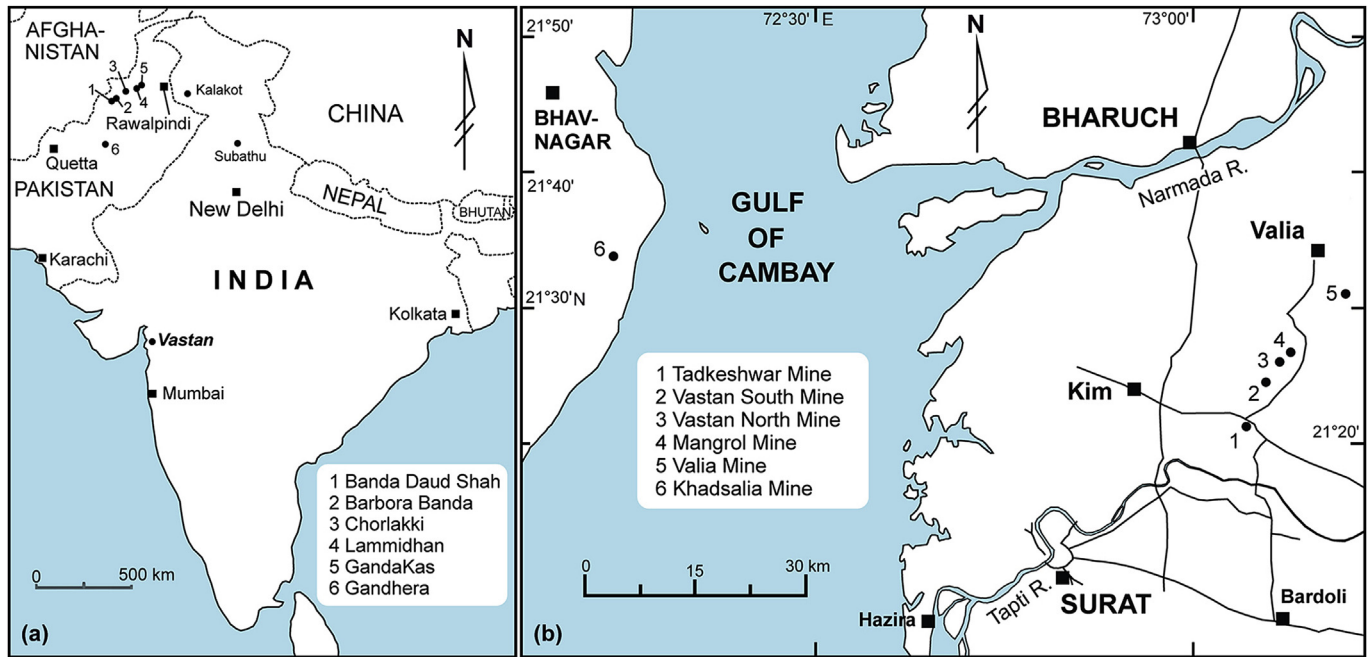


Figure 1. (a) Map of Indian subcontinent showing the location of early and middle Eocene terrestrial vertebrate localities including Vastan Lignite Mine. Squares represent major cities and black dots vertebrate localities. (b) Location map of the area around Vastan Lignite Mine, Surat District. Squares represent major cities and black dots lignite mines. Localities 1, 3, and 4 yielded terrestrial vertebrates.

Rose et al., 2006; Sahni et al., 2006; Bajpai and Kapur, 2008). The mammalian fauna of the Cambay Shale Formation includes the earliest modern mammals from the Indian subcontinent—with the highest diversity of early bats (Smith et al., 2007), the oldest lagomorph (Rose et al., 2008), the first Asian ailuravine rodent (Rana et al., 2008), primitive adapoid and omomyid primates (Bajpai et al., 2005b; Rose et al., 2007, 2009a), primitive artiodactyls (Kumar et al., 2010), the earliest Indian tapiroid (Smith et al., 2015), endemic perissodactyl-like cambaytheriid mammals (Bajpai et al., 2005a; Rose et al., 2014) — as well as more archaic groups, such as the first Indian tillodonts (Rose et al., 2009b, 2013) and basal hyaenodontid “creodonts” (Bajpai et al., 2009; Rana et al., 2015).

Other vertebrates include marine and non-marine fish (Rana et al., 2004; Nolf et al., 2006), the oldest birds of the Indian subcontinent (Mayr et al., 2007, 2010), a high diversity of terrestrial and aquatic snakes (Rage et al., 2008) and acrodontan lizards (Prasad and Bajpai, 2008; Rana et al., 2013), and the earliest ranid and bombinatorid frogs (Folie et al., 2013).

During the last decade our Indian-American-Belgian team has explored other lignite mines hoping to discover other vertebrate fossils in order to increase our knowledge of the early Paleogene faunas of the Indian subcontinent. In this pursuit, terrestrial vertebrates have also been found in the Mangrol lignite mine situated north of Vastan and in continuity with the same deposits. Here we describe the first vertebrate discoveries from the Tadkeshwar mine south of Mangrol and Vastan (Fig. 1). While the general lithology and the first discovered vertebrate remains from the Tadkeshwar mine present similar aspects to those of Vastan and Mangrol, with taxa of European affinities, several new taxa, especially among large non-mammalian vertebrates, indicate Gondwana affinities as well.

2. Material and methods

All the fossil vertebrate specimens from the Tadkeshwar lignite mine described in this paper were recovered from two horizons by quarrying the subsurface strata exposed by open-pit

mining operations. These fossiliferous continental sediments were also subjected to preliminary screen-washing through mesh of 1.5 mm.

Smaller remains were picked out and sorted in the laboratory under a binocular microscope. The material is composed of dental specimens and postcranial bones. All specimens from the upper fossiliferous horizon are originally brownish or dark in colour while specimens from the lower fossiliferous horizon vary from pale to dark in colour. To avoid oxidation and especially deterioration due to pyritization specimens have been coated with an acrylic resin (Paraloid B72) mixed with ethyl acetate solvent.

Larger specimens were coated (whitened) with ammonium chloride for digital imaging. Smaller specimens were photographed with an FEI Quanta 200 environmental scanning electron microscope at the Royal Belgian Institute of Natural Sciences in Brussels.

The present figured specimens are stored in the collections of the Wadia Institute of Himalayan Geology in Dehradun, and the H.N.B. Garhwal University in Srinagar, both in Uttarakhand state, India.

Abbreviations

- AV: Avenay, MNHN collections, France.
 CGM: Egyptian Geological Museum, Cairo, Egypt.
 GSI/PAL/CR: Geological Survey of India, Kolkata, India.
 GU/RSR: H.N.B. Garhwal University, Srinagar, Uttarakhand, India.
 MNHN: Muséum National d'Histoire Naturelle, Paris, France.
 MRAC: Musée Royal d'Afrique Centrale, Tervuren, Belgium.
 OCP DEK-GE: Office Chérifien des Phosphates, Direction de l'Exploitation de Khouribga, Geologie-Exploitation, Khouribga, Morocco.
 TAD: Tadkeshwar locality (2 levels, TAD-1 corresponding to the lower level and TAD-2 corresponding to the upper level).
 UM: University of Michigan Museum of Paleontology, Ann Arbor, Michigan, USA.

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